Structure from Motion Using Structure-less Resection

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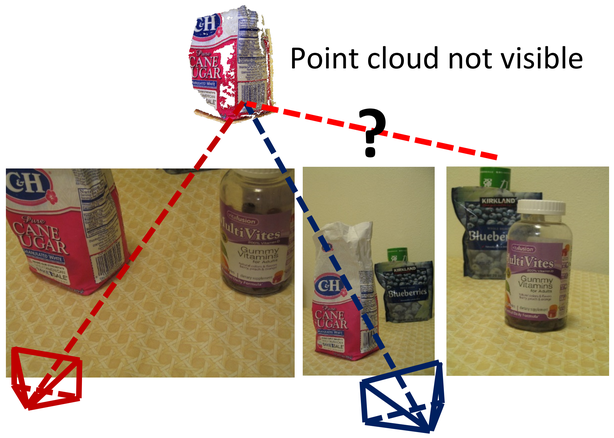
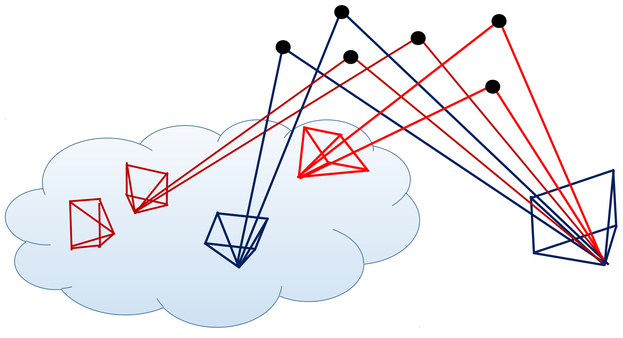
Motivation

- Traditional structure-based resection fails



Method overview

- Use pure 2D correspondences for resection
- Register a pinhole camera to the existing camera system



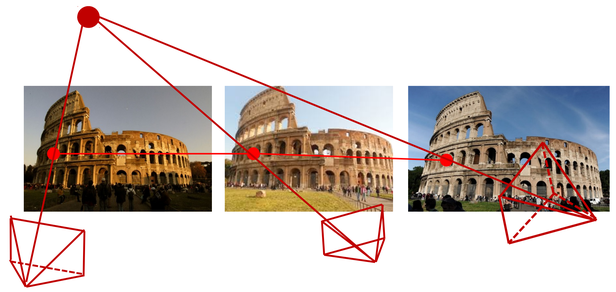
Related Work

- Fully generalized relative pose problem [1]
  - – Works only if the ray correspondences are 'general' enough.
  - *** Degenerate for many pinhole configurations**
- Non-minimal solutions using pairwise epipolar geometries
  - – From pairwise fundamental matrices [2]
  - – Global SfM formula from relative rotation and translation.
  - *** These methods do not guarantee exact ray intersections and cannot be used to maximize the ray intersections.**

[1] Henrik Stewenius, et al. "Solutions to minimal generalized relative pose problems". In Workshop on Omnidirectional Vision, 2005. (**We thank Henrik Stewenius for sharing his M2 code of this paper**)
[2] Sudipta Sinha and Marc Pollefeys, "Camera Network Calibration and Synchronization from Silhouettes in Archived Video", IJCV 2010

Highlights

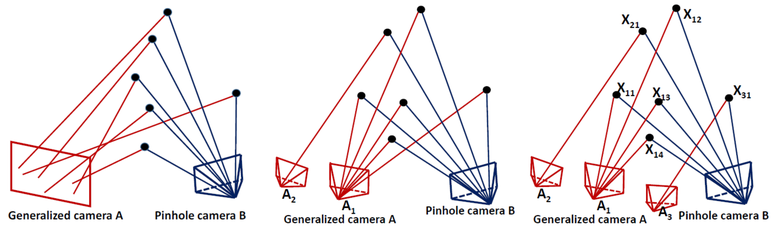
- New minimal solvers for structure-less resection.
- Reducing the minimal track size from 3 to 2 for resection.



- Improving completeness for incremental SfM

Minimal problem variations

- 6-point calibrated and 7-point uncalibrated problems
- The largest number of concentric rays |A1| among A



(a) 6-point problem, $|A_1| = 1$ (b) 6-point problem, $|A_1| = 5$ (c) 6-point problem, $|A_1| = 4$

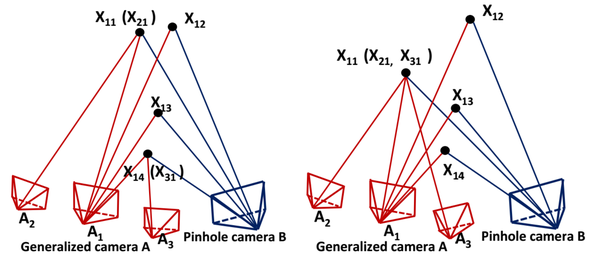
6-Point	$\|A_1\|$	6	5	4	3	≤ 2
	# of solutions	-	20	40	56	64
7-Point	$\|A_1\|$	6	5	4	3	≤ 2
	# of solutions	18	50	84	108	118

Minimal solvers

- Solvers for the 5+1 and 6+1 problems
  - – Based on the existing 5/6pt pinhole relative pose solver
- Solvers for the other problems (4+2, 5+2, etc.)
  - – Polynomial system based on generalized epipolar constraints
  - – Special care to the subset of pinhole epipolar constraints
  - – Special care to the redundancy of unknown focal length
  - – Solve with a Groebner basis method.

Special cases in real applications

- Structure is seen by multiple cameras



(a) (b)

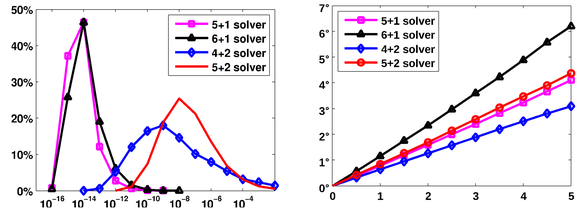
Figure 4. Possible configurations with replicated rays in camera B, where 4a still has 40 solutions, but 4b is unsolvable.

Results

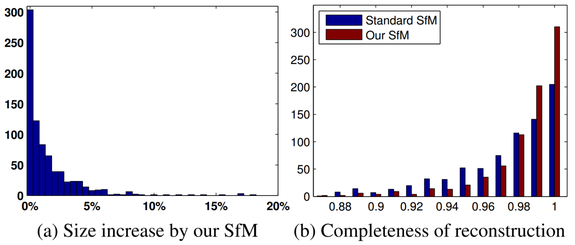
- Solver speed

Solver	5+1	4+2	6+1	5+2
Matrix	10×20	73×113	10×20	378×428
Time (ms)	0.048	1.2	0.046	13.6

- Rotation errors (noise-free vs noisy)



- Structure from motion model completeness



(a) Size increase by our SfM (b) Completeness of reconstruction

- Real image results